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**10.3.8 Ceramic Matrix Composites (Continuous Fiber
Reinforced) Thermal Protection Systems
by Salvatore R. Riccitiello, NASA ARC**



National Aeronautics and Space Administration

**SPACE TRANSPORTATION MATERIALS AND
STRUCTURES TECHNOLOGY WORKSHOP**

Salvatore R. Riccitiello
Ames Research Center, Moffett Field, CA

CERAMIC MATRIX COMPOSITES [CONTINUOUS FIBER REINFORCED] THERMAL PROTECTION SYSTEMS

BACKGROUND

- Initiated program with American Inc. to develop continuous fiber reinforced CMC thermal protection materials based on silicon carbide
- Reticulated low density ceramic foam core panel structures, based on silicon carbide, were fabricated and evaluated
- Reticulated silicon carbide low density foam susceptible to thermal shock
- "TOPHAT" thermal protection system utilizing a continuous fiber reinforced CMC and reusable surface insulation developed
- Single-ply/multi-ply continuous fiber reinforced silicon carbide CMC successfully evaluated, in the "TOPHAT" thermal protection system, to 3100° F

BACKGROUND cont.

- The carbon reinforced CMC material showed little degradation after a 100 minute exposure to surface temperatures of 2000° F and 2700° F
 - ★ The carbon reinforced CMC material showed little change in physical property after 100 minutes exposure to surface temperatures of 2000° F and 2700° F

CERAMIC MATRIX COMPOSITES [CONTINUOUS FIBER REINFORCED] THERMAL PROTECTION SYSTEMS

TECHNOLOGY GAPS

- High Temperature Continuous Fiber Reinforced CMC Materials
 - ★ Temperatures > 3500° F
 - High Strength / High Temperature Fibers
 - ★ Property Retention At Temperatures > 2200° F
 - High Temperature / High strength Matrices
 - ★ Property Retention At Temperatures > 2200° F
- Process Developments
 - ★ New Processes
 - ★ Shorter Fabrication Times

HIGHEST PAYOFF AREAS

- High Temperature / High Strength Continuous Fiber Reinforcements
 - ★ Temperatures > 3500° F
 - ★ Strength Retention > 3500° F
 - High Temperature Strengths Comparable To RT Strengths of present State-of-the-Art Fibers

**10.3.9 Thermal Protection Systems for Space Transportation
Vehicles by Howard Goldstein, NASA ARC**